

## Claims:

1. An optical switch comprising at least a light transmission portion, an optical path-changing portion and an actuator

5 portion; wherein

the light transmission portion has a light reflecting plane provided on at least one part of a plane facing the optical path-changing portion to totally reflect light, and light transmission channels having optical wave guiding bodies and being provided in at least three directions with the light reflecting plane as a starting point;

the optical path-changing portion is provided in proximity to the light reflecting plane of the light transmission portion in a movable condition and has an optical path-changing member for at least reflecting or scattering light; and

the actuator portion has a mechanism that is displaced by external signals and transmits the displacement to the optical path-changing portion; characterized in that

the switching or dividing of an optical path is carried out by contacting or separating the optical path-changing portion to or from the light reflecting plane of the light transmission portion by displacement of the actuator portion in response to the external signals;

so as to totally reflect an input light from the light transmission channels at the light reflecting plane of the light

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transmission portion and transmit it to a specific light transmission channel on an output side when the optical path-changing portion is separated from the light reflecting plane of the light transmission portion;

5           or take out an input light from the light transmission channel, reflect or scatter it at the optical path-changing portion, and transmit it to a specific one or more light transmission channel(s) on the output side when the optical path-changing portion is contacted to the light reflecting plane of the light  
10 transmission portion.

2.       The optical switch according to Claim 1, wherein the actuator portion has:

          a piezoelectric/electrostrictive element comprising a piezoelectric/electrostrictive layer and at least one pair of  
15 electrodes arranged on one part of the piezoelectric/electrostrictive layer;

          a vibrating member that is in contact with at least one part of the piezoelectric/electrostrictive element to support the piezoelectric/electrostrictive element and that converts strain of  
20 the piezoelectric/electrostrictive layer into bending displacement or vibrations;

          a fixing member to fix at least one part of the vibrating member so as to vibrate the vibrating member; and

          a displacement transmission member that is arranged  
25 between the optical path-changing portion and the

piezoelectric/electrostrictive element based on needs, and transmits displacement of the piezoelectric/electrostrictive element to the optical path-changing portion.

3. The optical switch according to Claim 2, wherein a ceramic  
5 substrate is constituted by unitarily firing the vibrating member and the fixing member, and a recessed portion or a hollow portion is formed in the ceramic substrate with giving the vibrating member a thin structure.

4. The optical switch according to Claim 2, wherein the  
10 piezoelectric/electrostrictive element comprises a laminated body in which an anode layer having linking multiple layers functioning as anodes and a cathode layer having linking multiple layers functioning as cathodes are alternately laminated with a ceramic piezoelectric/electrostrictive layer  
15 being put therebetween.

5. The optical switch according to Claim 1, wherein the light transmission portion comprises two or more layers having different light refractive indexes.

6. The optical switch according to Claim 1, wherein the light  
20 transmission channels of the light transmission portion comprises optical waveguide.

7. The optical switch according to Claim 1, wherein the light transmission portion is configured by joining at least two optical wave guiding bodies to one optical wave guiding body so as to  
25 form light transmission channels into at least three directions,

with the light reflecting plane of the light transmission portion as a starting point.

8. The optical switch according to Claim 1, wherein focusing lens or collimator lens is arranged at each of a plurality of

5 light-signal input ends and/or light-signal output ends of the light transmission portion, and light signals are input and output through the focusing lens or the collimator lens.

9. The optical switch according to Claim 1, wherein the optical path-changing portion has a light introduction member

10 made of a transparent material.

10. The optical switch according to Claim 1, wherein the optical path-changing portion has a light reflector for specularly reflecting light.

11. The optical switch according to Claim 10, wherein the  
15 light reflector for specularly reflecting light is a light reflecting film that is integrally formed on a plane of the light introduction member on the side of the displacement transmission member.

12. The optical switch according to Claim 1, wherein the optical path-changing portion has a light reflector for diffusely  
20 reflecting light or a light scattering body for scattering light.

13. The optical switch according to Claim 1, wherein the optical path-changing portion is constituted only by a light reflector for diffusely reflecting light or a light scattering body for scattering light.

25 14. A multichannel optical switch provided with a plurality of

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optical switches each comprising at least a light transmission portion, an optical path-changing portion and an actuator portion; characterized in that

the light transmission portion has a light reflecting plane provided on at least one part of a plane facing the optical path-changing portion to totally reflect light, and light transmission channels having optical wave guiding bodies and being provided in at least three directions with the light reflecting plane as a starting point;

the optical path-changing portion is provided in proximity to the light reflecting plane of the light transmission portion in a movable condition and has an optical path-changing member for at least reflecting or scattering light; and

the actuator portion has a mechanism that is displaced by external signals and transmits the displacement to the optical path-changing portion; wherein

the switching or dividing of an optical path is carried out by contacting or separating the optical path-changing portion to or from the light reflecting plane of the light transmission portion by displacement of the actuator portion in response to the external signals;

so as to totally reflect an input light from the light transmission channels at the light reflecting plane of the light transmission portion and transmit it to a specific light

transmission channel on an output side when the optical path-

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changing portion is separated from the light reflecting plane of the light transmission portion;

or take out an input light from the light transmission channel, reflect or scatter it at the optical path-changing portion, and transmit it to a specific one or more light transmission channel(s) on the output side when the optical path-changing portion is contacted to the light reflecting plane of the light transmission portion.

15. The multichannel optical switch according to Claim 14, wherein each light transmission channel in a plurality of optical switches is formed of a single light transmission portion.

16. The multichannel optical switch according to Claim 15, wherein each light transmission channel in a plurality of optical switches is crossed to each other and shares a part of each light transmission channel.

17. The multichannel optical switch according to Claim 14, wherein one input-side channel is linked to one output-side channel in series as for each optical switch; and light that is input from an input end of optical switches, is switched at each optical path-changing portion of a plurality of optical switches.

18. The multichannel optical switch according to Claim 14, wherein a plurality of optical switches are constituted by at least one optical switch having a plurality of input-side channels and at least one optical switch having a plurality of output-side channels, and one input-side channel is linked to one output-side

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channel between adjacent optical switches, switching the light input from input ends of a plurality of optical switches at the optical path-changing portion of the plurality of optical switches.

19. A multichannel optical switch according to Claim 14,

5 wherein a plurality of optical switches link one input-side channel to one output-side channel between adjacent optical switches by means of an optical fiber, switching at least the light input from input ends in an optical switch at each optical path-changing portion of a plurality of optical switches.

10 20. A multichannel optical switch in which a plurality of the multichannel switches according to Claim 17 are arranged in a row.

15 21. A multichannel optical switch in which a plurality of the multichannel switches according to Claim 18 are arranged in a row.

22. A multichannel optical switch in which a plurality of the multichannel switches according to Claim 19 are arranged in a row.

20 23. A multichannel optical switch comprising a plurality of the multichannel optical switches according to Claim 17; wherein each multichannel optical switch is arranged by locating at least one part of output ends themselves of each light transmission channel in each multichannel optical switch in an arc condition with an input end in an outer light transmission channel, which  
25 is disposed separately from each multichannel optical switch, at

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a center.

24. A multichannel optical switch comprising a plurality of the multichannel optical switches according to Claim 18; wherein each multichannel optical switch is arranged by locating at least one part of output ends themselves of each light transmission channel in each multichannel optical switch in an arc condition with an input end in an outer light transmission channel, which is disposed separately from each multichannel optical switch, at a center.

25. A multichannel optical switch comprising a plurality of the multichannel optical switches according to Claim 19; wherein each multichannel optical switch is arranged by locating at least one part of output ends themselves of each light transmission channel in each multichannel optical switch in an arc condition with an input end in an outer light transmission channel, which is disposed separately from each multichannel optical switch, at a center.

26. A multichannel optical switch in which an optical divider or an optical coupler is joined to a light-signal input end or a light-signal output end of each light transmission channel in the multichannel optical switches according to Claim 17 to branch or collect at least one part of the light transmission channel.

27. A multichannel optical switch in which an optical divider or an optical coupler is joined to a light-signal input end or a light-signal output end of each light transmission channel in the

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multichannel optical switches according to Claim 18 to branch or collect at least one part of the light transmission channel.

28. A multichannel optical switch in which an optical divider or an optical coupler is joined to a light-signal input end or a

5 light-signal output end of each light transmission channel in the multichannel optical switches according to Claim 19 to branch or collect at least one part of the light transmission channel.

29. A multichannel optical switch in which an optical demultiplexer filter or an optical multiplexer is joined to a

10 light-signal input end or a light-signal output end of each light transmission channel in the multichannel optical switches according to Claim 17 to branch or collect at least one part of the light transmission channel.

30. A multichannel optical switch in which an optical

15 demultiplexer filter or an optical multiplexer is joined to a light-signal input end or a light-signal output end of each light transmission channel in the multichannel optical switches according to Claim 18 to branch or collect at least one part of the light transmission channel.

20 31. A multichannel optical switch in which an optical

demultiplexer filter or an optical multiplexer is joined to a light-signal input end or a light-signal output end of each light transmission channel in the multichannel optical switches according to Claim 19 to branch or collect at least one part of the  
25 light transmission channel.

32. A multichannel optical switch in which each output end or each input end of a plurality of the multichannel optical switches according to Claim 17 is linked to a plurality of input ends or output ends in at least another multichannel optical switch.

5 33. A multichannel optical switch in which each output end or each input end of a plurality of the multichannel optical switches according to Claim 18 is linked to a plurality of input ends or output ends in at least another multichannel optical switch.

34. A multichannel optical switch in which each output end or  
10 each input end of a plurality of the multichannel optical switches according to Claim 19 is linked to a plurality of input ends or output ends in at least another multichannel optical switch.

35. The multichannel optical switch according to Claim 14, wherein the actuator portion comprises:

15 a piezoelectric/electrostrictive element having a piezoelectric/electrostrictive layer and at least one pair of electrodes arranged on one part of the piezoelectric/electrostrictive layer;

a vibrating member that is in contact with at least one  
20 part of the piezoelectric/electrostrictive element to support the piezoelectric/electrostrictive element and that converts strain of the piezoelectric/electrostrictive layer into bending displacement or vibrations;

a fixing member to fix at least one part of the vibrating  
25 member so as to vibrate the vibrating member; and

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a displacement transmission member that is arranged between the optical path-changing portion and the piezoelectric/electrostrictive element based on needs and transmits displacement of the piezoelectric/electrostrictive element to the optical path-changing portion.

36. The multichannel optical switch according to Claim 35, wherein a substrate of ceramics is constituted by unitarily sintering the vibrating member and the fixing member, and that a recessed portion or a hollow portion is formed in the substrate with giving the vibrating member a thin structure.

37. The multichannel optical switch according to Claim 35, wherein the piezoelectric/electrostrictive element comprises a laminated body in which an anode layer of linking multiple layers as anodes and a cathode layer of linking multiple layers as cathodes are alternately laminated with a ceramic piezoelectric/electrostrictive layer being put therebetween.

38. The multichannel optical switch according to Claim 14, wherein the light transmission portion is configured by joining at least two optical wave guiding bodies to one optical wave guiding body so as to form light transmission channels into at least three directions, with the light reflecting plane of the light transmission portion as a starting point.

39. The multichannel optical switch according to Claim 14, wherein focusing lens or collimator lens is arranged at each of a plurality of input ends and/or output ends of the light

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transmission portion, and light signals are input and output through the focusing lens or the collimator lens.

40. The multichannel optical switch according to Claim 14, wherein the light transmission portion comprises two or more  
5 layers having different light refractive indexes.

41. The multichannel optical switch according to Claim 14, wherein a light transmission channel comprising an optical wave guiding body is formed at one part of the light transmission portions.

10 42. The optical switch according to Claim 14, wherein the optical path-changing portion has a light introduction member made of a transparent material.

43. The optical switch according to Claim 14, wherein the optical path-changing portion has a light reflector for specularly  
15 reflecting light.

44. The optical switch according to Claim 43, wherein the light reflector for specularly reflecting light is a light reflecting film that is integrally formed on a plane of the light introduction member on the side of the displacement transmission member.

20 45. The optical switch according to Claim 14, wherein the optical path-changing portion has a light reflector for diffusely reflecting light or a light scattering body for scattering light.

46. The optical switch according to Claim 14, wherein the optical path-changing portion is constituted only by a light  
25 reflector for diffusely reflecting light or a light scattering body

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for scattering light.

47. The multichannel optical switch according to Claim 14,  
wherein each optical path-changing portion has a light reflector,  
and at least two kinds of specular reflection angles are shared  
5 among the optical path-changing portions.

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